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Crocodylomorph, turtle and mammal tracks in dinosaur-dominated Middle–?Upper Jurassic and mid-Cretaceous ichnoassemblages of Morocco

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ABSTRACT

We report tetrapod traces from two stratigraphic intervals in Morocco, and discuss their palaeoecological implications. In the first interval, crocodylomorph footprints assigned to *Crocodylopodus meijidei* are described from Middle–?Upper Jurassic continental fluvial red beds of the Isli Formation in the Imilchil region, Central High Atlas, Morocco. These traces are associated with a diverse dinosaur-dominated ichnofauna, including the footprints of theropods, ornithischians, sauropods and pterosaurs, together with numerous invertebrate traces. In the second interval, we report crocodylomorph swim traces assigned to *Hatcherichnus* isp., turtle trackways assigned to *Emydhipus* isp. and isolated mammal footprints in the mid-Cretaceous Midelt Formation, in the High Moulouya region, Morocco. These traces are, also, associated with a diverse dinosaur-dominated ichnofauna including theropods and ornithopods as well as pterosaurs and abundant invertebrate traces. Together with plant remains, conchostracans and fishes, findings indicate a diverse community populating a fluvial-brackish environment.

1. Introduction

Jurassic–Cretaceous tetrapod footprint assemblages are essentially dominated by dinosaurs, with theropods and sauropods representing the major components of the Jurassic ichnofaunas (Lockley and Hunt, 1995; Lockley and Meyer, 2000). Less abundant are ornithischians, although they can be more frequent on some surfaces (Olsen and Rainforth, 2003). In Lower Cretaceous strata, the most abundant ornithischian- and theropod-dominated ichnofaunas are known from North America, Europe and East Asia (e.g., Lockley, 1987; Pérez-Lorente, 2001, 2015; Lockley et al., 2006; Matsukawa et al., 2006; McCrea et al., 2014; Xing et al., 2015). Sauropod ichnofaunas can be more abundant locally (Farlow et al., 1989), as is the case for pterosaurs and birds (Lockley and Rainforth, 2002).

Generally, minor components in both ichnofaunas include crocodylians, turtles and mammals. In the case of crocodylians and turtles, this scarcity is partly related to the semi-aquatic lifestyle of many Jurassic–Cretaceous groups and the low preservation potential in subaqueous and inundated substrates (Klein and Lucas, 2015). Mammal tracks are generally rare in the Mesozoic, and crocodylomorph tracks have mainly been reported from small terrestrial forms and by traces of swimming individuals, in particular from the Jurassic–Cretaceous of Europe and North America (Olsen and Padian, 1986; Lockley and Meyer, 2004).

From the African continent, crocodylomorph tracks are scarcely known (Hadri et al., 2015; Mateus et al., 2017). Also, turtle tracks thus far have rarely been reported from this region (Belvedere et al., 2013). In recent years, Morocco has become one of the most important places for the study of Paleozoic–Mesozoic tetrapod footprint assemblages. Nearly complete successions with tetrapod footprints from this region

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